PROGRESS IN MATERIALS, METHODS, AND

SPECIFICATIONS FOR ASPHALT CONSTRUCTION

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Among the complex factors related to bituminous pavement construction are many with which I am sure you are familiar. These I shall omit and touch only on a few of those factors which I believe to be highly important to the progress demanded in the days ahead.

By progress with respect to materials, methods and specifications for asphalt pavement construction, we would necessarily mean the process of advancing or improving by marked stages or degrees.

The objective of progress is to construct asphalt pavements that will accomodate traffic demands; pavements that will normally have longer life; pavements that will require little or no maintenance during their normal life. In other words, pavements that will give us more and more service for the effort, materials, and dollars expended.

There never will be a time that materials specifications and construction technology will be so good or so perfect that they cannot be made better.

It is because of this assumption that I will make some statements which may eventually prove to be true.

Any statement one would make about asphalt pavement must necessarily be qualified to be strictly true so I will try to refrain from making specific qualifications as time will not permit.

The physical and chemical properties of asphalt pavements have been the subject of many investigations. The complications in the study of asphalt alone is difficult to explain - to say nothing of the complications involved when we add aggregates and climatic factors in one mixture.

We must understand as much as possible, the laws and forces of nature which work to establish a state of equilibrium in the earth materials we disturb.

We must conform with these laws to get the end results we desire. If we do not, our accomplishments will not be lasting.

It is certainly fortunate that we have long passed the stage where we began to get our money's worth in asphalt pavements.

There are still possibilities of getting more for our dollar and these possibilities should be thoroughly investigated.

GRADES OF ASPHALT

Today, many grades of asphalt are used. This is exclusive of cutbacks. We have good reason to believe one or two well-chosen grades could serve the majority of conditions.

One of the most desirable objectives in asphalt construction is to reduce the number of grades of asphalt. In our Standard Specifications, we have a wide choice. Many states have, in their own fashion, limited themselves to a very few of these grades. There is, however, wide variation in the states as to the grades selected, and perhaps little agreement as to which grades should be eliminated.

It requires a high degree of skill to get acceptable results when the asphaltic materials and solvents are combined in the manner set forth in the customary specifications.

It is true that the higher or harder the consistency of an asphalt beyond optimum, the higher and harder the immediate stability of the pavement.

However, at the same time, we are sacrificing plasticity, flexibility, workability, and the adaptability of the pavement to environmental change. Environmental change involves traffic, temperature, moisture, and slight volume changes in the base and subgrade.

Why is it not possible to arrive at what could some day be known as an optimum consistency asphalt?

Such a material could be used directly for plant mixing, a base for emulsions, a base for either kerosene or naphtha cutbacks or better still, a base for a compromise cutback -- a cut between kerosene and naphtha. It would have the heavy fractions of the usual naphtha and the light fractions of a kerosene.

It would be less volatile than naphtha and more volatile than kerosene. Such a cutback would require less aeration than a kerosene cutback and at the same time would be more workable than a naphtha cutback over a much longer time.

We should define optimum consistency asphalt as one which has the following characteristics: Sufficient but not excessive stability, plasticity or flexibility below freezing, a degree of reworkability, and resistance to hardening caused by direct oxidation.

We who have been thinking along this line believe a 300+ penetration asphalt would be about right. We believe it is quite possible we would find this consistency in the SC-5 range of viscosity.

We have evidence that plant mix, using SC-5 or even SC-4, gives excellent results.

Our experience and observation definitely points to a viscosity comparable with an SC-5 asphalt. This consistency has proven to be most tenaceous, durable, and most workable. It is flexible and plastic below freezing. It forms a rubber-like membrane over the pavement and protects inferior base material from surface water which would otherwise cause volume change and eventual pavement break-up.

OPTIMUM CONSISTENCY

With the high-viscosity penetration asphalts, the stability is relatively high after construction, but the aggregate particles are far from being interlocked in a state of mutual particle interference. Unless there are many months of hot pavement temperatures above the softening point of the asphalt, it is doubtful that the aggregate particles will ever reach a high state of consoli-

dation. The asphalt is rigid enough to carry the traffic and prevent aggregate consolidation.

This, however, is not objectionable, except for the initial cost, and the skill and timing required to construct a good pavement. It requires more compactive effort than usual to prevent a permeable condition in the pavement. Surface moisture and melting snow can penetrate the pore spaces during cycles of freezing and thawing, and cause immediate break-up.

The use of high consistency asphalts with softening points below hot weather pavement temperatures, will give us pavements that will not corrugate or bleed, providing the pore spaces are not immediately filled with asphalt. The asphalt is liquid in warm weather and the pore spaces will eventually be reduced by traffic compaction, thereby creating the danger of bleeding and corrugation. If the asphalt content is too low, the surface area exposed to hardening agencies is too great. Thus, the asphalt content is very critical.

Compaction under construction must be thorough in order to reduce the surface area exposed to hardening agencies. Interlocking of aggregate particles must be attained by compaction when the asphalt is liquid, otherwise, in cold weather surface water will penetrate the pavement and cause subgrade failure or break-up in the pavement.

The use of high consistency asphalts with softening points above hot weather pavement temperatures (ordinarily, will have penetrations at 77° F. below 50) will give us pavements that will not corrugate or bleed. The asphalt has strength and stability for all weather conditions. The oil content should be higher than the usual optimum. This is to insure the closing of the pore spaces by filling them with asphalt. This will reduce the surface area exposed to hardening agencies. The exact asphalt content is not critical. Such pavement would be adaptable to its environment under all conditions. With our presently produced asphalt there is a

question as to whether it is sufficiently plastic below freezing. This may be compensated by the high tensile strength of the asphalt. Air-blowing in the processing of the asphalt will also insure cold weather flexibility. Maximum strength in such a pavement is insured by careful compaction under construction.

In low-viscosity oil-aggregate mixes, high stability values are eventually obtained by traffic compaction. This is a continuous rearrangement of aggregate particles over a long period of time, until complete interlocking of the aggregate particles has been accomplished. The pavement has then reached its highest stability.

Now, a state of mutual particle interference in the aggregate prevails.

If the base and subgrade materials, with time and traffic, have consolidated along with the pavement, such a pavement will continue to give good service.

However, there are circumstances under which base and embankment consolidation have not kept pace with the surface hardening. Eventually, pattern cracking will follow. Surface water will then penetrate the pavement, and bring about volume changes, and loss of stability in the embankment material. A progressive break-up, with failure of the asphalt pavement, results.

If the materials and drainage in the foundation are good, a mat with pattern cracking will give good service for many years.

However, the best years of service in an oil mat are between the time of construction and the time that a condition of mutual particle interference in the aggregate occurs.

With the low-viscosity, slow-curing asphalts, the time required is relatively short (approximately ten years) for the pavement to reach a high state of consolidation and stability. Because of excessive lubrication, the pavement often becomes too hard and brittle.

This time is too short. We believe it can be increased several times by using what we call an optimum-consistency asphalt, which would increase the life

of an asphalt pavement without increasing the initial cost, and require less skill in the process of mixing and placing.

The optimum consistency of an asphalt is a consistency that would satisfy the required traffic volume and weight, along with the ability to remain flexible or plastic at temperatures below freezing. Such a consistency would allow the pavement to conform to the minor displacements that will occur in the best of granular base and embankment structures.

Optimum-consistency asphalt should be sufficiently plastic to lubricate the particles and allow them to approach a state of mutual particle interference: It should be thick and viscous enough to hold the particles on the pavement when used as a base for a cutback.

Medium viscosity (SC-5 - SC-6) asphalts have components in the oily constituents that are readily oxidized. However, before complete oxidation takes place, resulting in a hard asphalt, and while the asphalt is in a soft condition, it lubricates the aggregate particles. The asphalt under further compaction will become more dense and close the pore spaces.

This will exclude air and moisture and slow the hardening process. In effect, we will have a plastic, tough, weather-resistant pavement the stability of which will be adequate for all traffic.

As we have said above, optimum consistency should be somewhere in the viscosity range of SC-5 and SC-6.

VOLATILE CUTBACKS

Present standards are now so designed, that we must use many grades to satisfy all of our various aggregate materials and weather conditions, to say nothing of personal preferences.

For years we have been working with extremes, and not a happy medium. Too little applied science has been involved. (It is a marvel, we have generally had good results.)

A good job is often the combination of a degree of artistic skill and good luck.

The use of RC cutback is very limited.

We experience excessive volatiles in proportion to asphalt. As the asphalt is very hard, working time is limited; after the volatiles evaporate, it is not workable. For seal and cover work, it is too hard and brittle for cold-weather service.

We lose the volatiles before the work is finished, or they explode before we start.

Kerosene cutbacks are not volatile enough. The workable time is too long after coating or mixing is complete.

We are always cautioned that they require lots of aeration to get satisfactory results.

If you have to work a mixture to remove excess solvent, why put it in the asphalt in the first place?

The asphalt base of a kerosene cutback is ordinarily softer than the base of a naphtha cutback. It would be far more logical to use the soft base as a naphtha cutback and the hard base for kerosene cutback. However, the latter combination would still be limited in its usefulness.

From the consumers' point of view, is there a good reason for having two series of cutbacks — RC and MC?

We are working with extreme volatiles and asphalt viscosities which require skill and chance to obtain satisfactory results. Our experience has been that, after an operator has mastered one of these difficult combinations, he is very reluctant to try another. We can hardly blame him. He can easily attribute his occasional failures to other influences.

Of course, we would have our usual series 1, 2, 3, 4, and 5 grades, using the same base asphalt. These numbers represent only different percentages of

cutback in the asphalt, to make it adaptable to varying weather and aggregate conditions.

We have never had the experience of working with what some of us consider an ideal cutback, using an optimum consistency range of asphalt for a base, but we have found from field experience (other factors being equal) that any approach to such material gives us superior behavior (results).

OPTIMUM MOISTURE

There is a prevailing impression that asphalt and aggregate should be mixed and placed, as dry and as free of moisture as possible.

This is particularly true with reference to low-cost roads using low-consistency asphalts.

Moisture properly controlled will greatly increase the efficiency of processing and placing asphalt paving mixtures. The pavement will have immediate stability sufficient to carry the heaviest expected traffic.

The degree of interlocking of aggregate particles is the factor that determines the hardness, or mechanical strength, of a pavement.

Aside from the initial compactive effort, further interlocking is brought about by traffic, aided by the lubrication of the asphalt plus an optimum quantity of moisture, which is normally between 3 and 8 percent, depending upon the quantity and nature of the very fine fraction of the aggregate material.

It is interesting to compare asphalt aggregate-mix briquettes made in the laboratory, compacted at optimum moisture, with those prepared in the conventional manner, compacted without moisture (all procedures otherwise being the same).

The conventional briquette specimen, when first immersed in water for 24 hours, will frequently show a pattern cracking and a volume change in excess of 15 percent, with excessive loss of stability and density.

The briquettes prepared with moisture will have higher stability values,

greater density, low voids, low permeability, and will show little or no volume change when immersed in water for several days, then dried, and immersed again. The specimen will absorb and lose moisture without any change in volume.

We cannot prevent moisture from being absorbed by the mineral surface of aggregate particles.

Merely coating the particles with asphalt is not effective. It makes little difference whether the asphalt is thin, thick, or thoroughly mixed.

We may as well work at a moisture content that will satisfy the chemical affinity of the aggregate surface.

This affinity is a terrific force against which mechanical measures are of no avail.

When one observes a pavement that has pattern cracking on the shoulders and none in the traffic lanes; in fact, the traffic lanes are in perfect condition, it is evident that, during construction, success has been attained in keeping the pavement mixture dry. This is really doing things the hard way.

It is evident the aggregate materials are subject to swelling. This is a common reaction with our aggregates.

It is also evident that where there are no shoulders and the inslopes are steep, traffic avoids the edge of the pavement. When a vehicle does turn out of the traffic lane into the pattern cracking area, pavement break-up occurs because it has dried in a swelled condition and has lost its original stability.

The pavement has absorbed moisture since being placed. The compactive forces of traffic during the time the moisture was at an optimum, increased the density and stability in the traffic lanes.

On the shoulders, moisture caused the dry oil mix to swell and to increase in volume. As there was no compaction on the shoulders at the critical optimum moisture content, the shoulder pavement dried in a swelled condition, showing pattern cracking, with loss of density and stability.

If the shoulders could have been rolled and compacted at the time the pavement contained optimum absorbed moisture, the stability and density could be as good as the traffic lanes.

Slow-curing asphalts used in road-mix where initial stability values are low, the moisture, if not added during construction, will ordinarily be absorbed from vapors, and the condensation of ground water evaporation.

The quantity of water that will be absorbed, is limited by the natural affinity the aggregate material has for water. This amount of moisture will aid traffic in compacting the pavement, to a much higher degree of stability than would ever be attained if the moisture were not present.

If this were not true, and only oil and aggregate were combined in the mix, traffic would continually displace and shove the mix into windrows, rather than compact it into a serviceable pavement.

Experienced operators who have been most successful using the light slow-curing asphalts generally manage mixing and placing with an optimum quantity of moisture in the aggregate-asphalt mix. This some will do without being conscious of any moisture present, and, if questioned, will maintain the mix is very dry, at least containing less moisture than specification requirements.

A successful way of fighting forest fires is with fire. Perhaps a successful way of fighting moisture is with moisture.

For any asphalt-aggregate mixture there is an optimum moisture content where mixing is accomplished with relatively little mechanical effort. Placing and compaction to a required density also required little compactive effort. Greatly increased densities and stabilities can be attained with the usual amount of compactive equipment.

Optimum moisture in bituminous mixtures will, in the future, have just as much significance as it has had in soil embankment construction, and will have an important place in future specifications and construction methods.

At the present time, the use of moisture is an art confined to maintenance practice, rather than a science applied to construction through specifications.

HYDROCARBON UTILIZATION

The utilization of petroleum hydrocarbons by microorganisms has been known for many years.

It is only reasonable to suppose that asphalt hydrocarbons are as readily utilized.

Hydrocarbon microorganisms occur everywhere.

It is evident microorganisms are the primary agencies of hardening, of oxidation, and other chemical changes.

Soil bacteriologists know any organic material is eventually destroyed or altered by microorganisms.

When asphalt, which is an organic material, is placed in the environment of soil organisms, we can expect those organisms to feed upon the asphalt and change them. Both physical and chemical properties are changed by their metabolic processes.

These organisms can make the asphalt much more resistant to stripping from the aggregate in the presence of excess water and mechanical abrasion.

The temperature susceptibility can be decreased, which means a better quality product.

The temperature susceptibility can be increased, which means an inferior product.

They can also convert asphalt to carbon dioxide and water.

They can form polar compounds in asphalt which will combine with activated aggregate surfaces to form water resistant or insoluble metal soaps. This would increase the life of the pavement by eliminating asphalt stripping.

Different species of microorganisms can bring about different changes in asphalts.

The same species of microorganisms can bring about different changes in different asphalts.

The above reactions can be either harmful or beneficial to an asphalt pavement.

We have laboratory evidence that microorganisms will change the physical and chemical properties of asphalt.

The effects of soil organisms on asphalt can be studied by any arrangement or process that will allow comparison between a control asphalt aggregate mixture and a companion mixture innoculated with soil microorganisms.

The aggregate should be clean, open-graded sand (similar to Ottawa sand), free of minus two hundred (-200) mesh material.

The microorganisms may be obtained from any soil that for some years has been contaminated with petroleum hydrocarbons.

It is preferable to use old asphalt pavement because the organisms are adapted to the use of asphalt in their metabolic processes.

After some time, comparative analysis of the two extracted asphalts show a decided increased in the hardness of the innoculated asphalt.

Solvent separation of the asphalt into its components show decided changes in the relative percentages of oily constituents, resins, and asphaltenes.

For the most part, the resins increase at the expense of the oily constituents.

In areas where desirable soil organisms are deficient, we may find it good practice to innoculate the granular base material with bacteria, fungi, or molds before placing the pavement.

In some areas, we may find it necessary to use additives to retard the action of undesirable soil organisms. It is interesting to know that chlorinated phenols will retard their actions, and hardening of the asphalt may thus be prevented.

In dry regions, we may find it a good practice to innoculate, with beneficial cultures, the water used for base course compaction.

This would encourage fast action of bacteria or fungi. The retarding of ground water evaporation, by the asphalt pavement, will furnish the continuous supply of moisture that is necessary for organic growth.

In humid areas, the effect of soil organisms very likely will be beneficial and will, with time, improve the quality of the asphalt.

Further knowledge of hydrocarbon and soil microbiology will no doubt influence future changes in methods, materials, and specifications for asphalt pavements.

We must determine a desirable optimum consistency asphalt, an optimum diluent for cutbacks, optimum moisture for mixing and placing, and we should find means of utilizing microorganisms for improving pavement quality.

These are but a few complexities we must resolve since we desire to simplify and perfect the technology of asphalt pavement construction.